TEACHING PRACTICES THAT ENHANCE STUDENT MATHEMATICAL ACHIEVEMENT

by

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ABSTRACT

This study examines the effect that diverse teaching strategies have on students' mathematical achievement. Four teachers and their grade 8 students from the Nechako Lakes School District participated in this research project. A questionnaire was used to identify teaching strategies and assess teachers' level of innovation, based on the variety and frequency of teaching strategies they claimed to have used. To provide base-line data on student achievement, a pre-test was given in the fall of 2004, Comparisons with a post-test given at the end of the semester revealed students' mathematical improvement during the course.

This study provided information to the district about student achievement and teaching strategies that are likely to support the desired improvement. It showed that the teaching strategies used by the teachers can be expected to have an effect on mathematical achievement. This study was directly related to a district goal that involved a search for best practice.

This study concludes that varied teaching strategies are likely to enhance students' mathematical achievement.

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CHAPTER ONE: INTRODUCTION

A Need for Reform

Mathematics is such a necessary subject for young people to grasp in order for them to succeed in today's technological world. For six years I served on a mathematics committee whose primary goal was to increase mathematic literacy. Evidence of this was to be reflected in state and national standardized tests. The concern of mathematics literacy is common across North America.

In the Nechako Lakes 2004 Accountability Contract, which is a provincially required strategic plan for improvement, district officials write, "Analysis of the Fundamental Skills Assessment (FSA) numeracy results, school Comprehensive Test of Basic Skills (CTBS) results, government exam results for mathematics, letter grade distributions for mathematics, primary report card numeracy data and Computer Curriculum Corporation (CCC) Successmaker results in schools indicate that students in our school district are performing below expectations". (See figure 1). Some of the districts strategies for improving numeracy included having the District Mathematics Committee examine 'best practice' and up to date research, reviewing and scrutinizing exam results, assembling information with respect to current instructional practices used to teach mathematics in the district, and implementing the recommendation of both the Secondary Mathematics Teacher's Committee and the District Mathematics Committee. The district plans to continue acquisition of exemplary mathematics resources and to continue to support Successmaker (Accountability Contract of 2004).

	2002 target	2002 actual	target met	2003 target	2003 actual	target met	2004 target	2004 actual	target met	2005 target
% of primary students meeting expectations in numeracy on report cards					baseline 94%	-	95%	93%	no[1]	95%
CTBS numeracy Student National Percentiles Grade 3	-	47	-	-	49	-	50	48%	no[2]	50%
Grade 6	-	54	-	-	52	-	38	47%	yes	40%
Grade 9 (Quan. Thinking)	-	46	-	-	51	-	49	44%	no[2]	49%
FSA numeracy Grade 4	65%	74%	yes	66%	73%	yes	68%	73%	yes	70%
Grade 7	60%	74%	yes	62%	73%	yes	64%	80%	yes	66%
Grade 12 Math Exam Mean Score	72%	55%	no	57%	62%	yes	60%	60.0%	yes	62%

Figure 1. Results for numeracy achievement in the Nechako Lakes School District.

The district's search for 'best practice' intrigued me to join in this search. Through a literature review I came across teaching practices that have shown increases in student mathematical achievement. A variety of current practices can be found in Bennett and Rolheiser (2001a). They found student discourse, learning through activities and projects, and creating a classroom environment where strong interpersonal skills are cultivated is paramount in enhancing student success. In addition my search for 'best practice' led to brain research (Bennett &Rolheiser, 2001a) that gave insight as to why some strategies and techniques are more effective than others. The investigation revealed a need for teachers to adapt practices to include the most effective teaching strategies. Improvement will not just happen, but will require concentrated effort of each teacher to make gradual adjustments based on knowledge gained through educational research. Such change will require some teachers to step out of their comfort zones and try new techniques.

Vygotsky and the Present

I found Daniels' interpretation of Vygotsky's zone of proximal development could give teachers some insight for improving their instruction. Vygotsky, according to Daniels, believed in an invisible target that teachers are to aim for during their instruction time. At the bottom of the target are skills that the students are capable of doing without assistance. As the teacher aims higher the students need support with the skills or concepts. The higher the aim, more assistance is required until it is out of the student's ability to comprehend. One reason teachers conduct pre-tests is to gain information on student's prior knowledge. Now the challenge to teaching is taking the individual invisible targets of every student in the class and seeking the overlap. This overlap usually indicated a much smaller target for teaching a concept to the class. The bigger the class, the smaller the invisible target. The probability that a teacher can hit this target with one strategy is close to impossible. Thus, effective teachers are armed with many strategies, tactics, and methods that will meet the plethora of student needs.

During my last twenty years of teaching I have come across many different teaching strategies and curricula. I have tried to stay current with new trends that were promoted by curriculum publishers and school districts. My teaching experience has allowed me to work with hundreds of students throughout the years ranging from at-risk students who were in resource or remedial programs for mathematics to gifted and talents students who were taking calculus in grade eleven and twelve. In order to meet such a diversity of mathematics skills I looked for classes or readings that would improve my teaching skills.

My Personal Interest in this Problem

My education at UNBC in the Master of Education Curriculum and Instruction program has allowed me to take a more in depth look into the past, present, and future of teaching strategies. I have revisited teaching practices and considered new ones reflecting on the way I teach. As a result, I hope to provide information to School District 91 that will help them meet their goal of improving mathematics learning.

The need for improvement in numeracy is an area of concern at the provincial, national and international levels. However, one way changes are going to be made at these levels is if the school districts and mathematics teachers strive for this. I have internalized the desire for my students to achieve to the best of their abilities, realizing that part of that accomplishment depends on my willingness to improve how I teach. This means I need to become a reflective teacher who scrutinizes not only what my students are doing but also how I am teaching. Then my goal is to be willing to change to methods and procedures that are supported in research.

This interest led me to ask the following question.

Research Question

Does the variety of teaching strategies used by a teacher influence the mathematical achievement of the students?

Hypothesis

Students who are taught by teachers who use a variety of teaching strategies will obtain higher scores on a mathematical achievement test than will students taught by teachers who use less variety in their teaching.

In my literature review I explored strategies that improved the brain's ability to store information, how to create a classroom conducive to learning, the need for spoken and written discourse, the need for students to be actively involved in learning, and how to motivate students to participate and achieve mathematical success. My research objective was to prove that teachers who did these things have students who achieved more than students who were deprived of this variety and flexibility.

The need to improve numeracy is pertinent to Nechako Valley and important in my professional growth. My goal is to reveal research that will allow students the best chance to improve their mathematical skills in order to be more successful in the working world.

CHAPTER 2 – LITURATURE AND REFLECTIONS ON TEACHING

A Need for Change

In this section I revealed some reasons for changing how we teach, based on how it can affect the students. This is then followed up by changes educators can make that would address some of the adverse affects that some teaching styles may have.

Limitations of Traditional Teaching

There seems to be an epidemic of children being labeled in our school systems. Is society too quick to diagnose problems when, in fact, it could just be the educator's narrow view of how a child should learn and behave? Armstrong (1998) believes too many children are being labeled as learning disabled, underachievers, or with Attention Deficit Disorder (ADD) because the ways in which they think and learn are not being addressed by the linguistic or mathematical styles of teaching. According to him, tagging a child as ADD based on behavioral characteristics such as hyper- activity, impetuosity, and distractibility only, increases the likelihood of improper classification of the "racial- ethic- and linguistic- minority students". This is evident in the frequent over-representation of minority students in special education classes; at the same time these students are under-represented in the gifted/talented programs.

The child's lack of concentration, as Armstrong (1998) points out, might be better explained by changing conditions, in that students are busy with things like Nintendo, the Internet, and other fast paced electronic gadgets that make the traditional approach to teaching seem too slow paced and uninteresting. He believes the hyperactive nature or the distraction of a child could be due to other stressors in their lives like boredom, apprehension about being bullied, distress about a divorce, having allergies, or just a temperamental nature. According to Bennett and Rolheiser (2001a) "one out of six students are at risk" in Canada (p. 28).

As teachers, we have little power over students' learning styles, intellectual potency and limitations, ethnic origins, gender, at-risk, home situation, or the likelihood of learning disabilities. The burden of core curriculum and evaluation expectations, along with the limitation of time, contributes to the challenge of teaching (Bennett & Rolheiser, 2001a, p. 56). Teachers need to be cautious not to rely on the textbook as their principle resource for the curriculum, which could make their predominate instructional approach teacher- centered, so that the focal point of the learner is to find the 'one right answer' or duplicate the process the teacher employs (Kersaint & Chappell, 2001, p. 58). I have personally observed too many mathematics classrooms that could be described this way; the mathematics teacher shows the students how to work the problem and how to check their answer to see if it is the right one.

"Students have learned to survive mathematics courses; many attempt to compensate for their lack of understanding by memorizing mathematic procedures and formulas" (Simon, 1986, p. 41). When individuals learn, devoid of understanding, every new topic is learned as an isolated skill that can be applied merely to work out problems explicitly covered by teaching (Franke & Kazemi, 2001). There is a need to confront the prevailing style of mathematical instruction that compartmentalizes concepts and requires exact answers instead of constructing other options from students (Zevenbergen, Sullivan, & Moosley, 2001).

According to an internet article, (Accelerated Learning Network, 2003) subjects were taught in ways that concentrate on linguistic and mathematical intelligences, which are the foundation of most diagnostic evaluations like IQ tests. These are seen as "fairly good predictors of success at school because this is the way we teach (lectures) and the materials with which we deal (logically constructed books) depend heavily on these two intelligences" (p. 3). Armstrong (1999) argued that test results show a "decline in linguistic and mathematical achievements when compared with past results and those of other world cultures" (p. 1). This should prompt educational institutions and educators to take a serious look at school reform.

What Changes Need to Take Place

Teaching mathematics in a different way necessitates shifting to traditions of instruction that are, as Wood (2001) declares, "counterintuitive to the time-honored pedagogical practices" (p. 8). Suggested reforms require teachers to change from their conventional position as lecture-presenter to a role that stresses innovative expertise in scheduling and facilitating students' work (Simon, 1986, p. 41). Malmer (2000) states that this would require teachers to dispense with time-demanding arithmetic computations involving algorithms that now squander an unreasonable amount of time. He added that the heart of mathematics must be altered from counting to thinking. Battista (1999) asked, "How would you react if your doctor treated you or your children with methods that were ten to fifteen years out-of-date?" Out-of-date practice is precisely what occurs with the traditional teaching of mathematics (p. 1).

Teaching with a greater variety of strategies generates opportunities for learners to discover diversity in mathematics (Wood, 2001). Teaching this way not only entailed familiarity with the developing child and the content of mathematics but, more importantly, "knowing the points at which these two converge and deviate" (p. 2-3). Zevenbergen, Sullivan, and Moosley (2001) realized that the profession of teaching has the notion of teaching rather than learning as central to its work. They believed this emphasis needed to be redirected to "focus on the teaching of the students rather than the teaching of the concepts" (p. 6). Bennett & Rolheiser (2001b) believed a significant theoretical and pragmatic breach exists in knowledge about teaching of instructional practice. They also realized the process of teaching and learning is multifaceted; to engage in it efficiently is an extremely intellectual and innovative act.

When I first started teaching, I was always looking for the perfect way to teach. I tried every strategy that came along, imitated other teachers, and allowed the textbook to dictate what I did. After twenty years of experience, I realize that the knowledge of my subject is important as well as the many teaching strategies, tactics, and skills I have accumulated, but these mean nothing if I do not understand the students I am teaching. Now I have changed my thinking to focus on how to motivate students to learn. Armed with an increased understanding of human development, I am better equipped to fulfill many new and improved ways of teaching.

How the Brain Functions

In the section I will describe four pathways the brain uses to store information. The first is semantic memory, followed by procedural memory, emotional memory, and finally episodic memory. Understanding how the brain works better equips educators to choose strategies that enhance students learning.

Time-honored methods do not take into account recommendations by professional organizations in mathematics, and they do not take into account contemporary scientific studies on how students learn, commonly referred to as brain research. Teachers equipped with an understanding of how the brain works may make wiser choices on how to present the material effectively. According to Bennett and Rolheiser (2001a) the brain is a pattern seeker, and it forms these patterns through the assimilation of experience, reflection and neuron expansion. It lays down information in diverse pathways that are called semantic memory, procedural memory, emotional memory, episodic memory, and automatic memory. The authors also stated that teachers must access approaches that support the learner in discovering patterns and constructing meaning as well as encouraging the mind to work at more multifarious levels. This means that students should not just recall facts, but be expected to apply or evaluate information.

Graphic organizers can be used to aid the brain's pattern-seeking function by helping to file the information in easy to remember patterns. Teachers can use graphic organizers to systematize and present the material to the students. Students can use graphic organizers like brainstorming and Venn diagrams in a cooperative learning situation or during independent schoolwork.

Semantic Memory

Semantic memory frequently utilizes words or symbols to do things like recalling data, rules, and ideas (Bennett & Rolheiser, 2001a). They also said that semantic memory is the most complicated mode of constructing meaning and keeping information. Yet many times our teaching expectations emphasize this way of learning, for example we ask students to memorize and repeat multiplication facts or mathematic definitions.

Procedural Memory

Another type of memory is procedural, which is an unconscious, nondeclarative type of memory that cannot be put into words effectively and may not even cross the threshold of our consciousness. Procedural memory permits us to execute many physical skills mechanically. For example, when the traffic light turns red our foot automatically applies the brake. We do not consciously think, "the traffic light has turned red, therefore I need to lift my foot and apply pressure to the brake pedal so I can stop the car". Classroom routines, modeling and demonstrations allow information to be stored in this way.

Emotional Memory

Emotional memory is another path the brain uses to store information with a poignant framework that seems to be more readily evoked. By recalling an emotional situation we also more often than not can recall the particulars with modest effort (Parry & Gregory, 1998). According to Malmer (2000), "emotional factors play a very important part; early failures, anxiety, and worry often give rise to traumatic blocks, difficult to come to terms with" (p. 225).

Neurologists tell us that there are more neurons from the emotional part of the brain linking to the cerebral cortex than the reverse. The inference is that emotions are capable of highjacking the cortex in less than a moment's notice (Bennett & Rolheiser, 2001a). As educators, this reveals the "importance of actively teaching and reflecting on social, communication, and critical thinking skills" (p. 362).

Episodic Memory

Episodic memory stores information from our personal experiences. We can recall memories tied to events we have experienced, like our first day of school, high school graduation, the day we were married or the birth of our children. In a study done by Armstrong (1999), students were asked what things they liked to do in classes. They replied that they enjoyed being more actively involved and liked to work with classmates (p. 2). This supports Pappas, Kiefer, and Levstik (1999), who stated, "children are active, constructive learners" (p. 7) and learning is the result of allowing them to apply their ideas through discovery while participating in activities and projects that are saturated with dialogue.

Thinking back to the days in school, most memories are tied to events such as projects completed, plays and musicals presented, or participation in sports. How many people can recall explicit details of lectures heard? If lectures can be recalled it was probably because of prior learning or because the lecture pertained to something the person had a strong interest in.

Understanding the Problem

Ineffective Teaching

Research indicated that children have difficulties in traditional classroom environments that are boring, tedious, externally controlled, and have little semblance to real life (Armstrong, 1998). By changing classrooms to be more dynamic and invigorating learning environments to meet the needs of these children, teachers can expect to enhance the educational experiences of every student. Gardner (2000) suggested that learning about a topic in a variety of ways promotes retention and allows us to apply it in many new and unique ways.

Learning will increase when teaching becomes more pertinent to real life. If facts, rules and concepts are incorporated with procedures that arouse emotional enthusiasm through activities, the comprehension of students can be expected to escalate. The brain uses many avenues to store information, and the more that these memory pathways intersect the easier it is to remember new information. In hopes of increasing students' performance, recent research suggests that teachers should focus on how students learn or gain cognitive knowledge.

Bennett and Rolheiser (2001a) mentioned; that teachers should recognize that all students do not learn in identical manners nor identical rates, bearing in mind that the brain retains information that is considered to be important. Important information is meaningful, relevant, and authentic for the student. Dewey wrote, "From the standpoint of a child, the greatest waste in school comes from her/his inability to utilize the experiences [s]he gets outside of school in any complete and free way; while on the other hand, [s]he is unable to apply in daily life what [s]he is learning at school" (as cited in Pappas, 1999 p. 51).

Effective Teaching

Effective teaching is an evolving concept that keeps teachers reading, attending conferences, talking to others in the field, experimenting and always looking for better ways to accomplish student learning. The search to improve teaching abilities may include a look at how students learn and what a teacher can do to enhance this learning process. As a teacher I feel that everyone who walks into my classroom has the ability to learn, and it is my job to find out what I can do to help each student with that learning.

Knowledge about teaching and the subject matter is only half of the equation; a teacher must also have an understanding of the learning process.

Bennett and Rolheiser (2001a) found that concept knowledge and process knowledge are the most powerful predictors of student success. In addition, they believed effective teachers needed to appreciate the processes of change and how students gain knowledge over time. They also needed to develop skills to carry out specialized work in surroundings that support intelligence and innovative instruction.

Classroom Atmosphere

In this section I emphasize the importance of creating a classroom atmosphere. This type of environment does not just happen, but must be molded by the teacher. The diversity of the students should be acknowledged, and at the same time cultivated to bring out a class dynamic. Students should feel free to experiment or guess expecting mistakes to be made without fear of ridicule.

Diversity Acknowledged

Some of the issues that Zevenbergen, Sullivan,and Moosley (2001) have identified from sociological literature concentrate on the disparity between the cultural norm these students carry with them to school and those of the school environment. They pointed out that students come into the school context with community and cultural customs diverse from those of the school, so that teachers may perceive contributions based on these contexts as deficient.

Zenvenbergen, Sullivan and Moosley (2001) believed students' failure had less to do with some innate aptitude, than with failure to interpret the implicit policies of the game; that is, the traditions of the classroom. They noted, "Students must be able to unpack both the mathematical and the pedagogical practice in order to make sense of the interactions. However, some students, as a consequence of their familial background, will have a greater synergy with practices in the mathematics classrooms than their peers" (p. 3).

Instructional amalgamation is a component of how a teacher assembles a learning environment to meet the sundry needs of the learner (Bennett & Rolheiser, 2001a). All concur in theory that students ought to be treated differently from one another because of the uniqueness of their background and capability.

Diversity Embraced

Educators can take student diversities seriously by invoking an assortment of strategies and ways of working (Malmer, 2000). In so doing a teacher and students become a unique community of inquiry in all areas of curriculum (Wells, 2001). The shared style of instruction considers both the students' and teacher's schemas. It necessitates observant teacher reflection concerning interactions with students (Pappas, Kiefer, & Levstik, 1999).

In my own teaching, many times I found it easier to change my approach in presenting the material. Simply re-teaching a concept in the same way usually solicited the same response from my students. Observant reflection allowed me to change to better meet the students at their appropriate level of understanding.

Learning from Mistakes

This reflective approach to teaching (Schon, 1983) constructs an environment of security and permits students the autonomy to answer the problem in an original style. "A climate conducive to taking risks is required" (Pappas, Kiefer, & Levstik, 1999, p. 43) because "risk taking is inherent in the process of learning" (p. 14). The trepidation of getting an incorrect answer must be played down (Prescott, 2001).

Jones and Tanner (2001) believed that this learning environment can be accomplished by challenging the students to spot and correct intentional errors made by the teacher throughout explanations or examples. Learning from mistakes is a life skill we all need. As a result, "the attention of the class is drawn to common errors" (p. 20).

Errors can become opportunities for understanding, which Prescott (2001) surmised that any mistake from teacher or student could be explored as learning occurs. Jones and Tanner (2002) believed that the habit of spotting errors helped students to comprehend a numerical explanation but more importantly, it generated a sense of connection and ownership inside the classroom environment.

Franke and Kazemi (2001) stated that, "teachers need to develop ways to elicit and listen to their students' mathematical thinking". I have always encouraged students in my classes to explain, on their paper or verbally, how they derived the answer. Explanations were rewarded with partial credit in terms of grading, but more importantly gave me insight to the students' reasoning. With this information I could change my approach and correct any fallacies in understanding or fill in missing concepts through scaffolding.

Learning Through Discourse

In this part I emphasized the importance of written and verbal discourse. I described how constructive discourse does not happen, but one that teachers can develop. Discourse serves several purposes and has various benefits.

Learning to get along

Effective teachers create environments where students feel simultaneously challenged and safe (Bennett & Rolheiser, 2001a). The notion of what is safe and challenging in the classroom may vary for different students. To construct a community that works collectively toward common objectives while encouraging a diversity of views, individual leaning styles, personal initiatives, and originality, teachers must approach the task by investigation (Wells, 2001). Bennett and Rolheiser (2001a) recommended that teachers focus on constructing a setting that provide students with occasions to become skilled at disagreeing in an agreeable way, to take turns, to value everyone's right to be heard, and not put each other down.

Nussbaum (2002) pointed out that it is imperative to note that participating in argument-rich negotiations is normal for most students because they have experienced "oral argumentation with peers, siblings, teachers, and parents over privileges, possessions, social standing, and other issues of interest to children and adolescents" (p. 2). However, students need instruction on how to use these skills in a classroom setting (Larson, 1999). Therefore, according to Prescott (2001), instructors should train students to get along and resolve disagreements, because each student needs to experience success as a part of a team learning skills that [s]he will use throughout life.

Teacher's responsibility

Nussbaum (2002) agreed that the teacher's responsibility is to establish guidelines for the type of discourse acceptable in the classroom so that students experience a sense of security while contributing to discussions. One guideline for example could be to have the students phrase their disagreements in the form of a question. Ensuing disagreements shed light on where the student slipped off track in his or her computations, and leads to some wonderful mathematical revelations (Prescott, 2001).

Research overwhelmingly revealed that in unsafe classrooms the brain shuts down when it senses a threat. The hippocampus, which is vital in memory, deteriorates under prolonged stress (Bennett & Rolheiser, 2001a). The amygdula takes over the cerebral cortex; the emotions dominate. Emotional security can be threatened by something as simple as how the teacher asks or uses questions.

Bennett and Rolheiser (2001a) continued that children do not care to be singled out if they perceive that answering will make them look superior to or inferior to their peers. They believed that the unexpectedness or abruptness of being chosen removes the information from the student's head, as a result of the amplified level of anxiety due to no opportunity to prepare or reflect prior to being requested to reply.

Teachers can ease some of this anxiousness by pausing before expecting an answer. Findings from Bennett and Rolheiser (2001a) showed that wait time helps create a secure learning environment. They continued to report that most teachers' wait time is measured in hundredths of a second despite the fact that increasing thinking time to three or more seconds significantly improved student response. Cooperative structure such as Think/Pair/Share, Round Robin, and Place Mat provide opportunities for students to talk with one or two others without the stress of the whole class listening (Bennett & Rolheiser, 2001a).

"Real deliberations do not appear to be used by teachers as frequently as they should and teachers likely misuse the expression 'discussion' when they are really referring to 'lectures, recitation or other types of teacher-dominated classroom interactions'" (Larson, 1999 p. 2). Zevenbergen, Sullivan, and Moosley (2001) recommended a more social view of learning where teachers see the classroom and background of the students as being essential components of learning.

Benefits of Student Discourse

In social situations students spend a large amount of time learning the expectations for their behavior, asserted, Wood (2001). He continued, "Researchers claim that engaging in the normative practices of a culture also determine to a large extent the kinds of opportunities and learning experiences that directly influence a student's cognitive development" (p. 3).

"Spoken text is constructed collaboratively by the participants in a conversation" (p.15) and is a resource utilized to convey meaning to others (Pappas, Kiefer, & Levstik, 1999). Teachers need to "integrate speaking, listening, reading, and writing into their activities and projects" (Pappas, Kiefer, & Levstik, 1999, pp. 37-38).

Traditionally, classroom discourse reflects power and control. "Teachers not only do most of the talking but they also control how much children talk as well as the nature of their talk." Students are not given enough opportunities to take an open role in asking their own questions and they are seldom asked about their own strategies, views or feelings pertaining to their activities (Pappas, Kiefer, & Levstik, 1999).

The initial characteristic of children's learning is a social nature. The fact that rich group exchanges with others significantly add to students' prospects for learning, building, and sustaining these kinds of social conditions necessitates teaching in a different way (Wood, 2001). Rodrigues and Thompson (2001) agreed that "teaching and learning occurs in classroom settings where both teacher and students learn by negotiating new meaning through a linguistic framework" (p. 939). A collaborative style of teaching involves teachers sharing authority and power with their students is revealed during classroom dialogues (Pappas, Kiefer, and Levstik, 1999).

Reflecting upon this strand of literature, I understand that most of the learning done in my classes was through peer interaction, which allowed me opportunities correct any misconceptions and check for understanding before the students left my classroom that day. These casual assessments indicated to me students who needed help with the assignment and allowed me to scaffold my instructions to better bridge these gaps. I believe that such interaction encouraged students to stay on task physically and mentally with less anxiety.

Teacher's Support

Good questions become more important since the forms and types of questions posed by the teacher have the potential to impact on overall quality of the classroom environment (Zevenbergen, Sullivan, Moosley, 2001). Kersaint and Chappell (2001) thought that teachers should ask probing questions to assist students to discover the answers. They advised instructors to refrain from telling the students every detail of what to do or how to go about it.

Kersaint and Chappell (2001) also stressed the value in permitting students to decipher mathematical problems in ways that make sense to them. Zevenbergen, Sullivan, and Moosley (2001) suggested that students should work in small groups and develop their own framework for problems. The idea of meaningfulness was seen to be a vital factor in this approach.

Students should be encouraged to select techniques they are more comfortable with and in which they are most proficient. A comparative assessment of the merits of a teacher's or a student's approach could then be discussed (Jones & Tanner, 2002). Reflecting on this recommendation, I remember that I frequently encouraged my students to share alternative ways they may have solved a problem. Explaining their process not only took them to a higher level of understanding, but countless times provided the bridge that others needed to comprehend a particular problem solving approach.

Malmer (2000) affirmed that numerous assignments are, for the most part, appropriate for working in pairs. This form of collaboration presents students with many opportunities to talk about, and understand essential fundamental mathematical concepts. Wood (2001) recognized that meanings are "social products" shaped in and through interaction.

Furthermore, common understandings are needed as a basis of reference in interaction and communication; teachers are advised to listen to students. Scrutinizing discourse used in the classroom can give insight for understanding what students should learn, what they have learned, and how such knowledge has been received (Stone, 2002). This approach to reflection provides a quick oral assessment to check for understanding and reduced the chances of students reinforcing faulty procedures or thinking.

The Purpose of Discourse

When students are given opportunities to cooperate with each other and have discussions, they are presented with countless chances to reconsider, re-examine, and recreate how and what they mean. Studies on cooperative learning suggest that tasks typified by intricacy and indecision promote an advanced level of student-to-student discourse (Nussbaum, 2002).

According to Pappas, Kiefer, and Levstik (1999), knowledge is always affected by culture and existing social circumstances because people are social beings. The authors also believed knowledge is reorganized as a product of experience, structured and assembled by each learner through group interactions. Zevenbergen, Sullivan, and Moosley (2001) wrote students should be given many opportunities to talk about mathematics in an environment where they have substantial support to increase essential skills for group work and discussion. They also stated that children learn more when collaborating with others than doing hours of seatwork in which talking is forbidden.

Studies at the university level demonstrated that in classes where the university lecturer stopped every eight to ten minutes and allowed students to discuss what was just presented, students' exam scores almost doubled when compared with students who took notes during the entire lecture (Bennett & Rolheiser, 2001a).

If, as the literature suggested, intelligence is greatly affected by social interaction, should teachers not then be responsible for creating learning environments that encourage students to talk in meaningful and engaging ways? According to Bennett & Rolheiser (2001a) the development of this interpersonal intelligence is the most important predictor of achievement in life.

Teachers need to incorporate strategies for leading a student or group of students to a goal, by evoking or scaffolding a particular style of thinking (Strong, Perini, Silver, & Thomas, 2004). Pupils who struggle to discover correct vocabulary to express their thoughts need to be scaffolded with hints (Jones & Tanner, 2002): "when students re-explain someone else's thoughts they have to analyze the explanations in order to compose their own attempts"(p. 271). Paraphrasing requires students to think about how a partner's rationalization measures up to their own mathematical understanding. A teacher should only mediate when it is crucial to center concentration on important aspects of mathematics.

Zevenbergen, Sullivan, and Moosley (2001) considered open divergent questions to elicit an array of acceptable answers more encompassing than closed inquiries employed in majority teaching circumstances. Students can respond at a level that is fitting to and corresponds to their present level of understanding. These authors believed such responses might not surface when closed-divergent questions are asked; open-divergent questions give the instructor more knowledge of the students and their levels of comprehension. When students offer responses that reveal their level of perception, diversity in the classroom is accommodated (Zevenbergen, Sullivan, & Moosley, 2001).

The teacher, as the person with proficient knowledge, is responsible for selecting the thinking strategies and for choosing methods that will direct the dialogue to a predestined solution. The teacher's questions focus attention on important features of the problem that may not otherwise be understood (Jones & Tanner, 2002). This means that teacher awareness of when students do not recognize a concept allows for intentional teaching and scaffolding, which increases the chance that important knowledge and skills will be attained by the students (Morell, Flick & Wainwright, 2004).

The use of language in the classroom by a teacher and students is now thought to influence social development and the students' disposition toward mathematics. This view is supported by Baxter, Woodward, Voorhies, and Wong (2002) who claim that students learn more when they explain "how they derived their answers by using words, numbers, and pictures", which gives them a better grasp of difficult mathematical concepts (p. 175).

Written Discourse

Spoken language is only part of classroom discourse. Written text is also critical to learners. Writing cultivates "individual thinking and reminds the students that learning and thinking are active, not passive" (Countryman, 1992 p. 14). Writing gives an additional opportunity for delayed reflection and helps students strengthen metacognitive self-knowledge.

Writing permits students to structure and compose answers and compare alternative methods (Jones & Tanner, 2002). Morell, Flick, and Wainwright (2004) stated, "Self-reflection is an important way to get students to move from lower levels of thinking to higher levels of thinking"(p.7). Therefore, it is very important for students write what they have learned and how they learned it.

Countryman (1992) affirmed that when students write they become aware of what they know or what they would like to know, and they connect prior knowledge with what they are learning. This view is supported by Bennett and

Rolheiser (2001a), who believed that the more learning correlates to the students' past, current or future knowledge and experience, the greater the likelihood the students will be drawn into the learning. Countryman (1992) believed journals offer a way to enhance self-confidence and participation by decentralizing power, promoting independence, providing an alternative form of assessment, monitoring progress, enhancing communication, and recording growth.

Learning through doing

In this part I present the need for students to be actively involved their education and how a teacher can foster this need. I include some positive examples of this approach, and reasons why teachers may be hesitant to implement this approach.

The Teacher's Responsibility

The teaching of mathematics in a school where students memorize facts, follow instructions, do homework, and take tests makes little sense to many students because they cannot explain what an answer means. In order to understand mathematics children need to be doing mathematics. "A classroom that allows for greater interaction through which students can clarify tasks or create more meaningful or relevant contexts from their problems is desirable" (Zevenbergen, Sullivan, & Moosley, 2001, p. 5-6).

How teachers convey their expertise in a student-centered environment or for teacher initiated activities and inquiries always requires a "search for best fit" (Pappas, Kiefer, & Levstik, 1999, p. 51). Wells (2001) asked how teachers might go about implementing curricular topics so that students will be led into a more exploratory approach to learning, but where instruction is "reconciled with the requirements imposed by a pre-structured curriculum and closely specified learning outcomes" (p. 7). In answer to this question he added that the endorsed curriculum must be a "persuasive spirit of inquiry" (p. 7).

Simon (1986) put forth the belief that "mathematical concepts require far more than a laissez-faire approach". A preferred more intricate and challenging type of teaching requires teachers to inspect the cognitive arrangement of concepts to be taught and then construct sequences of experiences that present students the occasion to investigate the domain and ascertain these concepts. Countryman (1992) added that children needed to be actively involved in order to comprehend the subject they are studying.

It follows, then, that educators need to create a practical application of subjects throughout the curriculum so that students are encouraged to be active, innovative, and responsive to the world around them. Teachers can then be kid-watchers who evaluate their students' learning while the students are in the midst of the activities (Pappas, Kiefer, & Levstik, 1999).

What Students Need

"School mathematics needs to be presented as consisting of problem-solving, reasoning, and communication; a view that places mathematics within the context of children's developing understanding of their world, both cognitive and social aspect" (Wood, 2001, p. 2). Simon (1986) advocated cooperative learning situations in which students work together in pairs or small groups as an essential part of the mathematical learning experience that maximizes the benefits of exploration and discovery. "In this environment the teacher gives up the role of imparter of information and becomes the architect and facilitator of active learning" (p. 42).

Once a cooperative learning atmosphere has been created, a teacher can use a more collaborative style of teaching. This style of teaching, according to Pappas, Kiefer, and Levstik (1999) provides teachers with many openings to offer advice to children as they take on activities and projects. At times the teachers can "lead from behind" by tracking what students are doing and providing them with support needed to attempt new things on their own that initially they could not do with out help (p. 45).

Positive Results

When students are permitted to "discover mathematical concepts for themselves and refine problem-solving skills in small groups they learn mathematics and self-reliance" (Simon, 1986, p. 40). This approach fosters learning with understanding, according to Franke and Kazemi (2001), and goes beyond linking new knowledge to existing knowledge. And takes into account identifying knowledge to produce rich integrated knowledge configurations.

Learning with understanding occurs when students sense learning as being driven by their own inquiry. Thus students reflect on a concept more intensely and construct representations and clarifications of it that unite with their previous knowledge in a personally important way. As a result the students retain their understanding of the concept longer (Simon, 1986). Countryman (1992) puts it this way,

> I believe that to learn students must construct it for themselves. They can only do that by exploring, justifying, representing, in short, by being actively involved in the world. The process of acquiring something by exposure to models, a process of trial and error, and practice within social groups allows for acquisition without direct teaching. (p. 2)

This style of teaching requires more preparation time up front than other styles of teaching. Students may also need extra time to explore or discover. I have come to believe that such time is well spent. From my experience, I believe, students stay more engaged, interested, and motivated. In the long run, increased mastery of the material saved time because students needed less review and I did not need to re-teach concepts.

Another hesitation for leaving the more traditional style of teaching may be that educators do not know how to implement or may not be aware of the more innovative approaches. As learners, the teachers need to be taught and encouraged to make the desired modifications.

Malmer (2000) believed diversity between skills and knowledge needs to be stressed. Some students, those with dyslexia for example, may have trouble with algorithms but can still be extremely advanced problem-solvers. Kersaint and Chappell (2001) observed that lessons focused on problem solving kept the students engaged, actively contributing, and appearing to take more pleasure in mathematics, in fact, "the students demonstrated that they were able to do mathematics" (p. 63). My learning experience is a testimony to this, not only did I learn despite my dyslexia, but I so loved the journey that I majored in mathematics and have taught the subject for many years.

Learning through being engaged in activities is paramount in promoting student learning. It is not just doing activities that are important but allowing students to interact with each other that promotes overall learning. If students are interested in what they are learning and the way they are allowed to learn, their active behaviors can be channeled constructively instead of disruptively. I can attest to this. I have seen many at-risk students not only find success in mathematics, but also show improved behavior, attendance, and attitude.

In 1977, Haug, Bennett, Jamieson, and Krause in Edmonton Alberta Public School system conducted an action research project, which used an outdoor curriculum with at-risk students. (as cited in Bennett & Rolheiser, 2001a). Academic classroom time was cut in half so that the second half of each day could be taught outside the classroom. During the afternoon students were involved with activities that applied the skills they were learning in the classroom. Over time the students in the innovative curriculum did as well or better on academic tests than those who had a more intense academic emphasis.

Reasons Teachers Resist Change

Many teachers may believe they do not feel they have the time to incorporate activities and projects during the class time and cover the many learning objectives mandated by the government and school systems. In the study just mentioned, students participating in the outdoor curriculum finished the necessary learning outcomes by December. All the materials were finished in one semester, with typical academic time only in the morning, one-fourth the usual time. As an added bonus the attendance rate of these at-risk students rose from 78% to an average of 95%.

Motivated to Learn

How to motivate is a hard concept to explain. In this section I mention how and who to motivate. In addition I share what motivates and what does not.

Who and How to Motivate

Motivation is a key to students wanting to be in the class, having a desire to contribute to the class in a positive way, and to put forth the effort needed to learn the material. Students who are doing well academically and have a healthy self-concept require successful experiences about 75 % of the time. Students who are not doing well in school and do not have a healthy self-concept require successful experiences at least 90% to 95% of the time (Bennett & Rolheiser, 2001a).

The need for at-risk students to have more successful experiences makes sense, but I do not believe this is being actualized in classrooms today. Far too often the students who are doing well are given verbal reinforcement and written encouragement by receiving good grades on their assignments. However, students who are having difficulty are often verbally corrected, and have papers with lower grades. Such grading practices contribute to a deterioration of student self-confidence and reduce students' desire to put forth effort.

Teachers continuously struggle to find ways to motivate learners. What is appealing for one student may not be exciting or important for others (Bennett & Rolheiser, 2001a). "An effective teacher is continuously assessing students and pedagogy as [s]he works through a program of study" (Zevenbergen, Sullivan, & Moosley, 2001, p. 2-3). Motivation depends on accomplishments, awareness of results, accountability, significance of the subject to the student, and interest (Bennett & Rolheiser, 2001a). The use of open-ended assignments and questions provides tremendous teaching and learning opportunities but also valuable assessment information (Zevenbergen, Sullivan, & Moosley, 2001).

What Motivates and What Does Not

Judging by their classrooms and their conversations, many educators believe that students need to be quiet and remain seated in neat little rows while the teacher teaches, in order for learning to take place. However, research does not support this approach. According to Prescott (2001), mathematics is so much more than calculations. Students are not motivated with worksheets or textbook assignments, but by lessons associated with games and stories. It is better to keep practice work to a minimum, he continued, and instead focus on building enthusiasm and real-world skills through multidimensional projects.

Gardner (2000) believed the need to memorize a myriad of facts is obsolete today when one can carry around a palm pilot or search the web to retrieve the information needed. He also believed the capacity to think is very different from knowing vast amounts of information. He suggested that learning about a topic in a variety of ways promotes retention and allows us to apply new knowledge more effectively and creatively.

Key mathematical topics require students to study subject matter in four dimensions, "procedurally, conceptually, contextually, and investigatively" (Strong, Perini, Silver, & Thomas, 2004, p. 4). In a study by Wheatly (1984), problem solving was the first unit taught, and it was stressed throughout the year. New importance was placed on problem solving together with the use of manipulatives and a fixed paced or benchmarked program. "There was a major shift from a rule-oriented to a process-oriented curriculum" (p. 52). This approach was found to be more proficient and successful, and also very inspiring. Wheatly found that students in this class experienced a forty-point increase on a standardized test in only two years.

In order for students to apply mathematics with self-confidence, they must have occasions to learn actively by discovering concepts and communicating their thoughts to their peers. Building on an understanding of cognitive procedures, "the teacher is the architect and facilitator of this approach", (Simon, 1986, p. 43) infusing innovative life into the classroom and allowing students to develop into powerful problem-solvers.

Wood (2001) believed that situations of perplexity and the conflict of ideas with which students are permitted to struggle are exactly the setting that encourages learning with understanding. Therefore, in order to produce these circumstances for the mathematic learning in classrooms, teachers must resist their normal tendency to enlighten students, make the task easier, or intervene and carry out part of the assignment.

Wood (2001) believed the practice of mathematics in many schools put emphasis on the learning of particular skills to a definite proficiency level with teachers directly coaching the students. Currently the pedagogy is more broadly conceived and involves the growth of more multifaceted and complicated forms of interaction and dialogue that places students, rather than teachers, at the heart of instruction (p. 2).

Strong, Perini, Silver, and Thomas (2004) realized that diverse approaches do not rely on merely using this or that strategy. But it is a mindset to "commitment and growth, helping students see themselves in a better light, a belief in challenging all students and giving them a feeling of accomplishment, a sense of community, where every student knows that he or she has something special to contribute, and a determination to create a solid curriculum, one informed by a clear sense of purpose, a magnet-like relationship to assess, and a belief that curriculum should offer all students a way up, not a way out" (p. 5). The curriculum and teaching styles need to be more flexible and the teaching styles need to be more varied.

Becoming a Better Teacher

Teachers need to stay abreast of the newest educational studies that pertain to their field of study as well cultivate awareness of the development of the particular students in their classes. Some current areas that effective teachers are using include cooperative learning, the need for discourse in the classroom, and the need to teach from a more constructivist approach by planning activities and projects that lead students to understanding. Teachers should know what a typical student in their class is capable of doing, and then differentiate lessons for students who may require additional support of challenge (Tomlinson, 2003).

According to Morell, Flick, and Wainwright (2004) the foremost rudiments of the transformation of teaching revolves around a constructivist outlook of teaching and learning, and consists of techniques such as encouraging discourse between students, sustaining inquiry and problem-solving, and supporting students in thinking about their own education. Teachers, according to Kersaint & Chappell (2001), can be very uncomfortable with the unforeseen and are therefore hesitant to reform.

Jones & Tanner (2002) believed that teachers must have a capacity to predict likely answers and mistakes, self-confidence to go where students may lead, and, at the same time, the ability to navigate the lesson to accomplish its objectives. Rather than promoting a typical instructional format, it is these subtle, varied educational aptitudes that need to be enhanced in order to develop the quality of teaching and learning of mathematics. To summarize, the achievement and performance of a collection of teaching tools is a trademark of successful teaching (Bennett & Rolheiser, 2001b).

Focusing on a student's mathematical thinking continues to be an significant means for amalgamating pedagogy, mathematics, and students understanding together according to Franke and Kazemi (2001). They proposed that, as teachers struggle to construct sense of their student ideas and engage in investigations, complex problems are created, questions are posed, interactions transpire, mathematical objectives are accomplished, and learning increases.

No solitary model of teaching can successfully meet all students' needs and provincial curriculum objectives that teachers face. Therefore, an astute and efficient teacher will build up a reasonable level of mastery and flexibility in the use of an array of teaching methods. Teachers can learn and implement several models of teaching into their regular classroom practice (Bennett & Rolheiser, 2001a).

Summary

In summary, a child needs a physically and emotionally safe place to grow. Students need an environment that stimulates the emotions and provides experiences that capture and sustain their attention. The brain seeks patterns of routines and organization. It remembers what is important and what it likes. Students crave social interaction with others and an environment that is not boring but enriched which in turn stimulates learning.

Too many children are dropping out of school, or not receiving the skills they need to be successful in today's world. "If students cannot compute accurately, explain their ideas, discover solutions, and apply mathematics in the real world; they do not know mathematics" (Strong, Perini, Silver, & Thomas, 2004, p. 3). A considerable body of research has been provided to suggest that the number of dropouts could be significantly reduced if educators would take a more innovative approach to teaching. The assumption is that students who are more actively engaged in their leaning will learn more.

Teachers need to create learning atmosphere in their classroom and teach what is relevant to the students in the world today. Educators should also teach in ways that inspire inquiry and discourse, stepping out of the more traditional style into a more interactive, student-centered, way of teaching. There is so much to learn, so much to do, but efforts that teachers invest in this challenge are very likely to yield results in the form of student achievement.

In a commencement speech, a mathematics teacher from Nova Scotia's Dartmouth High School, Mr. Armand Viera shared that

> "The road of their lives began at the chair where they were sitting that very minute. On the road away from that chair, be conscious of the opportunities to make the moment for the people you encounter. Let your humanity pour out of you." (p. 2)

For many years Viera's motto for his students was "Failure is not an option!" Teachers have opportunities to impact many lives; therefore failure should not an option. (Humphrey, 2000, p. 2).

CHAPTER THREE: METHODS

The purpose of my study was to inquire whether a wider variety of teaching strategies used for mathematics teaching in a local context would, in fact, enhance student achievement. My primary focus was on the teachers: how they taught, and the techniques they used. To test my hypotheses that a wider variety of strategies would be more effective, I first surveyed the teachers to assess the variety of their methods. Then I tested students with a pre-test and post-test to see which class showed the most improvement over the course of the semester.

This chapter contains three sections. The first section deals with the primary participants the teachers and the secondary participants the students. The second section describes the questionnaire used to profile the teachers in terms of their instructional strategies and the tests used to observe the improvement in the student's mathematical knowledge. The final section is a detailed description of data collection procedures.

Participants

The participants were educators who taught grade eight mathematics in the first semester in School District #91. This district #91 is the school district I live in and I was in agreement with their goal to improve numeracy and the methods through which they proposed to accomplish improvement. A total of four teachers from different high schools took part in the study. The teaching experience of the four ranged from novice to veteran.

Sixty-seven students from two high schools were my secondary focus. Consent forms were not necessary since I had no direct contact with them. In addition, the results from the pre-test and post-test were not used to evaluate the students, but to evaluate the effectiveness of the teaching strategies.

Instruments

Questionnaire

Based on my literature review I developed a questionnaire that would reveal the variety of practices used by each teacher. See Figure 2. The first page was a checklist of methods that were part of the teacher's instructional repertoire (Bennett & Rolheiser, 2001a) and the frequency with which they used them. These items focused on the teachers and how they presented the material, including whether they lectured or used notes, and how often they modeled or demonstrated procedures for the students. These items gave me some insight to the role of the instructor.

Student work was another section on this page. I wanted to know if the students worked individually, in pairs or groups, if written assignments were required, and whether the students were allowed to discuss mathematics as they completed their work. Much of the literature reviewed indicated that it was important for the students to work together and talk about mathematics. Technology provides another means of presenting mathematics material that motivates some students. I wanted to know if the students used computer, calculators, or did they watch videos. Using these technologies allow students to get past the mechanical skills and able to see the concepts more clearly. I also wanted to know if the students were involved in activities, long-term, short-term, discovery, or problem solving. Research supports the need for students to be actively involved with mathematics concepts, not just paper and pencil assignments (Bennett & Rolheiser, 2001a).

	Daily	Weekly	Per/unit	Seldom
PRESENTATION OF MATERIAL				
Lectures (oral)	____	____	____	____
Notes (written out)	____	____	____	____
Demonstrations	____	____	____	____
Modeling	____	____	____	____
STUDENT WORK				
Individually	____	____	____	____
Pairs	____	____	____	____
Group	____	____	____	____
Discussions	____	____	____	____
Written	____	____	____	____
Use computers	____	____	____	____
Use calculators	____	____	____	____
Videos	____	____	____	____
Manipulatives	____	____	____	____
Long-term activities	____	____	____	____
Short-term activities	____	____	____	____
Discovery activities	____	____	____	____
Problem solving activities	____	____	____	____
ASSESMENT				
Written (Traditional)	____	____	____	____
Oral	____	____	____	____
Portfolios	____	____	____	____
Rubrics	____	____	____	____
Journals	____	____	____	____

Figure 2. First page of teacher questionnaire.

The final section on the first page of the questionnaire dealt with the types of assessment the students encountered. I included these items because the literature indicates that written assessments are the most common, but less traditional methods are beneficial, for example the use of portfolios, rubrics, and journal entries. Alternative assessments provide less stressful ways of testing understanding and usually offer students more time to reflect on the material. These assessments are more motivating because students know up front what is expected, and how it will be graded.

The second page of the questionnaire was designed to help me understand some of the background information the teachers drew from in preparing their lessons. Were they aware of research on Multiple Intelligences, Bloom's Taxonomy, or graphic organizers? Did teachers present story problems as a unit or scattered throughout the year? And did they teach the mechanics and/or the concepts of mathematics problems? I concluded the questionnaire by asking the teachers to provide a sample of a typical lesson and the amount of time allocated for the different sections.

This questionnaire was designed to offer insight as to how teachers conducted their classes without direct supervision. The feedback from this survey was the crux of the investigation because it was used to determine which teacher used more variety his or her approach to teaching. The information was then used to determine the treatment groups. The term innovative was used for the teacher whose practice had the most variety and the term traditional was used for the other teachers. Student improvements between these two groups were then compared.

Pre-tests/Post-tests

The District Mathematics Achievement Tests (DMAT) from the Prince George School District for grade 7 and 9 were used in this study. Twenty-three multiple-choice questions from each test were combined with ten additional questions. I created ten anchor questions to target grade 8 mathematics topics. In composing these anchor questions I referred to the recommended learning outcomes posted by the provincial government as well as several grade eight textbooks presently or previously used in School District #91. Anchor questions based specifically on the curriculum were included to better detect growth during the current mathematics year under the tutelage of the respective grade eight teachers.

The pre-test (DMAT 7) gave baseline data for each student as they entered the school year. The post-test (DMAT 9) was compared to the students pre-test to determine mathematical growth for the grade eight year. Dr. Peter MacMillan recommended these tests based on his knowledge of their validity and reliability. The anchor questions were checked for validity and reliability with the use of the ITEMAN program.

Procedures

The pre-tests were delivered to the teachers at the beginning of the semester and administered by the instructors. Upon the completion of the tests the data, consisting of every student answer for each test question was entered onto a spreadsheet. The ITEMAN program was used to analyze this data to view how well each question functioned. This process was repeated with the post-test toward the end of the semester.

The ITEMAN (version 3.5) analyzes item response data and provides an item analysis statistics for each item, which permits the researcher to determine a) the degree to which each item is contributing to the reliability of the test and, b) how well each response alternative is performing for each item. The program also provides statistical indicators, including the mean, standard deviation, and reliability for the performance of the whole test and the anchor questions.

The questionnaire was delivered to the teacher at the same time as the pre-test. When the questionnaires were returned I analyzed the results qualitatively to determine the most innovative teacher, based on the number of different teaching strategies and the frequency with which they utilized them. This information was then used to divide the teachers into two groups, with the descriptors "innovative" or "traditional". The students of these teachers were then assigned to their respective treatment groups. The data collected from the students was then analyzed with SPSS programs to see if there were significant differences in the students' performances as they related to the teachers' strategies. Other factors such as gender and ethnicity were explored to differentiate if they could have caused or influenced some of the mathematical gains.

CHAPTER 4: RESULTS

The results for the study will be discussed in three sections. The first section deals with the findings from the teachers' questionnaire, and based on these findings a revised research question and hypothesis was made. The second section presents the results of the pre-tests and the post-tests taken by the students. The final portion reveals the results of the relationship between the students' progress and the teacher style of teaching.

Analysis of the Teachers' Questionnaire

Questionnaire Results

Upon examination of the questionnaire completed by the teachers one teacher's practices seemed have greater variety. Teacher A used 77% of the items on the first page with a daily or weekly frequency as a result was chosen as the innovative teacher for purposes of this study. (See Appendix E) Teacher B used 59% of the items daily or weekly and the other two teachers C and D used 54% of the items with this same regularity as a result these teachers were labeled as traditional teachers to provide clarity for this study.

Teacher A used real life applications to connect the mathematics material to the students' prior knowledge; taught the concepts as well as the mechanics behind working the mathematical problems; taught social skills and encouraged discourse in the classroom. This teacher used Bloom's Taxonomy for both written and oral questions and considered the Theory of Multiple Intelligences when deciding how to best present the material. Teacher A used graphic organizers and presented story problems throughout the year. The other teachers did many of these as well, but none of them reported variety and/or frequency of use to the extent of that reported by Teacher A.

I interpreted the data to conclude that Teacher A appeared to have the most innovative teaching style. Based on my hypothesis, I expected the students in class A would show the most improvement on their post-test when compared to the other students. Therefore a revised research question and hypothesis was made.

Revised Research Question

Will students taught by a teacher A show more improvement on the post-test than the students in the other classes?

Revised Hypothesis

Students in Teacher A's class will improve more on their post-test than students in the other classes.

$$H_0:\ \mu(A) - \mu(B) = 0$$

$$H_1:\ \mu(A) - \mu(B) \neq 0$$

where A refers to the mathematics improvement in Teacher A's class and B refers to the mathematics improvements in the other classes.

Results of the Pre-tests and Post-tests

After the post-tests were taken, I checked that each student had completed a pre-test and a post-test. Ten students did not take the pre-test, so their post-tests were eliminated. Fifteen students did not take the post-test, so their pre-tests were eliminated. One more student was removed because a page had been unanswered in the pre-test. Therefore, the data from twenty-six students was incomplete and could not be used in the study.

Pre-test

The pre-tests consisted of twenty-three multiple-choice questions selected from the District Mathematics Achievement Test (DMAT7) for grade seven. Ten additional multiple-choice questions, or anchor questions, were added specifically to target grade eight mathematics. The students' choices for every question were entered into a spreadsheet then the ITEMAN program was used to analyze the results. A sample of the output from this program can be seen in Table 1.

The first column refers to the test item, the second column; proportion/percentage correct indicates the number of students, who answered the item correctly. The Index of item discrimination (Disc. Index = $P_{High} - P_{Low}$) supplies information about the test items effectiveness in discerning between the students who scored in the in the upper 27% and those who preformed the in lower 27% of the test. This difference should be positive for the correct answer and negative for the wrong answer. This means that more students who performed well on the test should get the correct answer to any one item than those students who did not perform as well. The students with lower scores would be expected to choose an incorrect response on any one item more often than students with higher scores. If the answer is too easy there may not be a big difference between the groups. In test item 1 (see Table 1) the difference between the two groups for the correct answer is .27 where it is .67 for item 2. This would indicate that item 2 discriminates better than question 1.

Table 1

Partial Output for DMAT 7 from ITEMAN

Seq. No.	Prop. Correct	Disc. Index	Point Biser.		Prop. Total	Endorsing Low	High	Point Biser.	
1	.81	.27	.18	A	.08	.05	.05	-.13	
				B	.09	.21	.00	-.42	
				C	.81	.68	.95	.18	*
				D	.01	.05	.00	-.14	
				Other	.00	.00	.00		
2	.67	.43	.25	A	.10	.11	.10	-.11	
				B	.04	.05	.00	-.12	
				C	.67	.47	.90	.25	*
				D	.18	.37	.00	-.53	
				Other	.00	.00	.00		

The point-biserial correlation, found in the fourth column, shows the relationship between the correct responses on the item and the total scale scores. If positive, it means the examinees scored reasonably high on the scale as a whole got this item correct. If the point-biseral correlation is negative it means that scores of the students that picked the correct option were relatively low. A positive number is preferred for the correct keyed answer where the other options should be negative. In the last column the point biserial (r_{pb}) is -.13 for choice A, -.42 for choice B, .18 for choice C, and -.14 for choice D. The correct choice is marked with an asterisk and it is the only one that has a positive value; a sign this test item performed well. Note question number two, the incorrect answers have a negative point biserial and the correct choice, C, is positive. This indicates that question two is also performing well.

The remaining columns provide alternative statistics similar to the first columns, but they are calculated separately for each response alternative. The total proportion/percentage, column six, indicates the percent of all students who chose this answer. The seventh column, low, indicates the proportion/percentage of students who chose this response whose over all performance was in the lower 27%, where the eighth column, high, indicates the percent of students for the upper 27% who chose this alternative. Notice alternative A for question 1: 8% of all the students selected this choice, 5% from both the high and low groups, leaving a negative correlation. Alternative C for question 1 is as follows: 81% of all students selected this choice, 68% from the lower group and 95% from the higher group that provides a positive correlation.

The difference between the high and low, columns 7 and 8 reveals the discrimination between the two groups, indicating the effectiveness of the question on this test. When $D > .4$ these test items are said to show great discrimination. Average discrimination happens when $.3 < D \leq .4$, and acceptable discrimination is $.2 < D \leq .3$. Marginal discrimination occurs when $D \leq .2$; these are the questions we need to scrutinize.

Table 2 was created to summarize the information for the pre-test. It includes the discrimination index for the whole test (D), the proportion/percent (p) of students or each of the alternatives for every test item, and the correlation (r_{pb}) it has with the rest of the test. Each item can be examined to see how well it is performing.

Table 2.

ITEMAN Summary of the Pre-test.

Item	***D***	p	r_{pb}	p	r_{pb}	p	r_{pb}	p	r_{pb}
1	.27	.08	-.13	.09	-.42	**.81**	**.18**	.01	-.14
2	.43	.10	-.11	.04	-.12	**.67**	**.25**	.18	-.53
3	.27	.03	-.31	.01	-.14	**.81**	**.18**	.15	-.28
4	.16	**.91**	**.11**	.04	-.22	.04	-.19	.00	---
5	.11	.00	---	**.94**	**.11**	.01	-.02	.04	-.28
6	.43	.07	-.15	.09	-.35	**.72**	**.32**	.10	-.32
7	.58	.07	-.11	.10	-.52	**.72**	**.33**	.09	-.32
8	.54	.33	-.22	.06	-.33	**.48**	**.29**	.13	-.44
9	.39	.33	-.32	**.27**	**.23**	.10	-.21	.25	-.22
10	.38	.18	-.27	**.48**	**.14**	.27	-.15	.07	-.39
11	.70	.24	-.28	.31	-.54	.07	-.25	**.36**	**.52**
12	.44	.12	-.21	.27	-.14	.25	-.42	**.34**	**.19**
13	.16	**.79**	**.01**	.16	-.31	.03	-.03	.00	---
14	.48	.06	-.08	.10	-.35	**.75**	**.36**	.09	-.52
15	.01	.12	-.16	**.85**	**-.02**	.03	-.14	.00	---
16	.23	.39	-.29	.03	-.19	**.52**	**-.04**	.06	.07
17	.26	**.85**	**.20**	.07	-.25	.06	-.33	.01	-.06
18	.58	.01	-.06	.01	-.18	**.79**	**.46**	.18	.62
19	.21	.00	---	.04	-.44	.04	-.17	**.91**	**.27**
20	.50	.10	-.40	.15	-.26	.10	-.19	**.63**	**.32**
21	.27	**.79**	**.15**	.13	-.24	.06	-.26	.01	-.22
22	.63	.04	-.28	.10	-.48	.07	-.34	**.76**	**.55**
23	.04	.16	-.05	.18	-.08	.12	-.36	.53	.00
24	.43	**.40**	**.15**	.22	-.28	.19	-.42	.15	-.49
25	.53	.25	-.62	**.66**	**.24**	.01	-.22	.07	-.28
26	.52	.19	-.52	.15	-.31	**.52**	**.13**	.12	-.39
27	.30	.13	-.34	.06	-.32	**.73**	**.12**	.06	-.39
28	-.17	**.12**	**-.31**	.75	.25	.06	-.31	.07	-.12
29	.37	.13	-.34	.10	-.47	.21	-.30	**.54**	**.05**
30	.30	.39	-.53	.31	-.19	.07	-.31	**.22**	**.09**
31	.68	.18	-.44	**.43**	**.38**	.13	-.31	.25	-.60
32	.31	.22	-.42	.16	-.18	**.40**	**-.03**	.10	-.25

The questions are categorized as follows:

Great discrimination: 2,6,7,8,11,12,14,18,20,22,24,25,26,31

Average discrimination: 9,10,29,32

Acceptable discrimination: 1,3,16,17,19,21,27,30

Marginal discrimination: 4,5,13,15,23,28

Focusing on the questions with marginal discrimination, correct answers were as follows: 91% for Item 4 ($D = .16$), 94% for Item 5 ($D = .11$), 79% for Item 13 ($D = .16$), and 85% for Item 15 ($D = .01$). The students in the higher group performed better on all of these questions than students in the lower group. My interpretation is that these were just very easy questions, not to be unexpected on a pre-test. Correct response for Item 23 ($D = .04$) was 53%. However it was discovered that Form A did not have a correct alternative, and therefore this item was omitted.

Post-test

Table 3 has the summarized results for the post-test. Taking these into account, the performance of the questions can be inspected.

Great Discrimination ($D > .40$): 1,4,8,11,12,13,16,17,18,19, 21, 23,26,27,29,30,31,32

Average Discrimination ($.3 < D \leq .4$): 2,10,14,22,25

Acceptable Discrimination ($.2 < D \leq .3$): 5,6,7

Marginal Discrimination ($D < .2$): 3,9,15,28

Focusing on the questions with marginal discrimination, correct answers were as follows: 93% for Item 3 ($D =-.01$), 85% for Item 9 ($D = .20$), and 94%

for Item 15 (D = 94). The students in the top 27% performed better than the students in the bottom 27% with the exception of Item 3, which was insignificantly (.01) smaller. The small discrimination value is likely due to the questions being easy.

Item 20 was removed because a class omitted it because of a typing error. A decision was made to remove Item 20 from the pre-test as well to keep the number of questions equal. Anchor question, Item 23 was removed even though it performed well because it had been removed from the pre-test due to an error. Item 28 was removed because it had not performed well on the pre-test. This left 21 questions from the main part of the test and 8 anchor questions. For Item 28 (D = -.27) only 12% answered correctly and the lower group was performed better (20%) than the higher group (4%) that makes the correlation negative. Thus the question was omitted.

Table 3

Scale Statistics Provided by ITEMAN

Item	***D***	p	r_{pb}	p	r_{pb}	p	r_{pb}	p	r_{pb}
1	.50	.01	-.09	.16	-.50	**.79**	**.5**	.01	-.40
2	.33	**.81**	**.34**	.03	-.11	.12	-.51	.04	-.11
3	-.01	.01	-.22	.04	.07	.01	-.40	**.93**	**.09**
4	.61	**.54**	**.43**	.09	-.34	.27	-.32	.10	-.35
5	.29	.04	-.30	.00	---	.06	-.28	**.90**	**.28**
6	.28	.04	-.18	.07	-.08	.12	-.46	**.76**	**.28**
7	.25	.04	-.18	**.82**	**.19**	.09	-.22	.04	-.23
8	.53	.09	-.38	**.60**	**.38**	.07	-.17	.24	-.37
9	.20	.06	-.36	**.85**	**.29**	.06	-.34	.03	-.00
10	.39	.34	-.20	.09	-.19	**.45**	**.29**	.10	-.44
11	.44	**.60**	**.34**	.15	-.13	.10	-.40	.13	-.39
12	.60	**.36**	**.44**	.22	-.24	.21	-.35	.21	-.33
13	.46	.04	-.44	.07	-.44	.04	-.25	**.84**	**.55**
14	.40	.21	-.11	.16	-.27	**.55**	**.20**	.04	-.23
15	.13	.00	---	**.94**	**.28**	.01	-.22	.04	-.32
16	.53	.27	-.41	**.63**	**.40**	.03	-.31	.07	-.28
17	.65	**.42**	**.47**	.37	-.53	.06	-.17	.15	-.20
18	.47	.10	-.49	**.33**	**.32**	.21	-.33	.36	-.06
19	.70	.31	-.59	.03	-.15	**.64**	**.49**	.01	-.22
20	---	---	---	---	---	---	---	**---**	**---**
21	.54	.25	-.13	.12	-.30	.09	-.41	**.54**	**.25**
22	.32	.09	-.10	**.76**	**.35**	.07	-.31	.17	-.50
23	.71	.12	-.25	.07	-.42	.10	-.37	**.71**	**.52**
24	.61	**.48**	**.24**	.25	-.45	.16	-.39	.09	-.17
25	.41	.16	-.45	**.12**	**-.19**	.58	.09	.13	-.39
26	.46	.04	-.33	.06	-.37	.15	-.44	**.75**	**.25**
27	.40	**.54**	**.10**	.12	-.24	.22	-.44	.12	-.36
28	.24	.54	-.36	**.24**	**.04**	.09	-.25	.10	-.24
29	.75	.03	-.24	.10	-.56	**.75**	**.49**	.12	-.53
30	.31	.34	-.36	**.31**	**.14**	.12	-.38	.19	-.30
31	.49	.15	-.42	.31	-.33	**.42**	**.17**	.12	-.42
32	.37	.15	-.27	.15	-.25	**.49**	**.05**	.15	-.38

The pretest statistical results are shown in Table 4. N of items refers to the number of items with the DMAT 7 questions separated from the anchor questions. The anchor questions were compared to the anchor questions on the post-test. The other N refers to the number of students who took the test.

Table 4

Statistical Summary of Pre-test.

Scale:	DMAT 7	Anchor
N of Items	21	8
N of Examinees	67	67
Mean	14.507	3.910
Variance	9.623	2.589
Std. Dev.	3.102	1.609
Skew	-0.292	0.167
Kurtosis	-0.732	-0.643
Minimum	7.000	1.000
Maximum	20.000	8.000
Median	15.000	4.000
Alpha	0.648	0.339
SEM	1.839	1.308
Mean P	0.691	0.489
Mean Item-Tot.	0.228	0.141
Mean Biserial	0.320	0.181
Max Score (Low)	12	3
N (Low Group)	19	26
Min Score (High)	17	5
N (High Group)	20	24

The mean is the average of items correct on each part of the test; this means that about 4 out of 8 questions were correct on the anchor questions. The standard deviation distributes the scores around the mean. For a normal distribution or curve approximately 96% of the students would be within two standard deviations for the mean; for this test most would fall between 21 and 8 question correct for the main part of the test, and between 7 and 1 for the anchor questions.

Skewness indicates how close the distribution is to being normal. The negative skew for the DMAT proportions indicates that a few more students fell below the mean than above. The anchor portion had a positive skew that indicates more students were above the mean than below it. The median is the fiftieth percentile score, meaning that half of the examinees scored better than this score and half had a lower score. Since the median and the mean are close (15 and 14.5 for the first portion and 4 and 3.9 for the anchor questions), this test has a rather normal distribution of scores. The maximum score (low) corresponds to the highest score for students in the bottom 27%; there are 19 students in this group. Minimum score (high) refers to the lowest score included in the top 27% of the students who took this test; there were 20 in this group.

The post-test statistical summary is shown in Table 5. Both tests had a minimum of one question correct for the anchor questions and a maximum of eight. On both tests there were three students with the minimum score and only one student with the maximum score.

Comparing the pre-test and post-test, the mean had a slight increase from 3.910 to 4.313 while the median remained the same. The minimum and maximum scores remained the same on the anchor questions but changed on the first portion from 7 and 20 on the pre-test to 2 and 21. This shows that scores were more dispersed but it should be noted that this portion was made up of grade nine level questions. Looking at the anchor questions the maximum low score (3) stayed the same while the lowest high score went up by one.

Table 5

Statistical Summary for the Post-test.

Scale:	Dmat 9	Anchor
N of Items	21	8
N of Examinees	67	67
Mean	14.030	4.313
Variance	15.701	2.932
Std. Dev.	3.962	1.712
Skew	-0.552	0.042
Kurtosis	0.118	-0.838
Minimum	2.000	1.000
Maximum	21.000	8.000
Median	15.000	4.000
Alpha	0.786	0.430
SEM	1.832	1.293
Mean P	0.668	0.539
Mean Item-Tot.	0.341	0.194
Mean Biserial	0.472	0.254
Max Score (Low)	12	3
N (Low Group)	24	24
Min Score (High)	17	6
N (High Group)	22	19

Analysis of the Test and Questionnaires

With this information I divided the data into two groups. Teacher A's group would be the innovative treatment group and the other teachers would be together as one traditional treatment group. The results are shown in Table 6. The results of the pre-test were compared to the results of the post-test for each student. The students in the two treatment groups were then compared with the independent t-test to see if there was any significant difference between the two groups. The average mean difference for these eight questions was .941 for the innovative group and .220 for the traditional group; which can be calculated as 4.2 times higher.

The independent-sample t-test shows there is significant difference (t >2) between the group A and group B because t = 2.133. (t = 2.133, df = 16, p = .049) A test called the Cohen's d, which takes the mean difference divided by the standard deviation, ie .941 ÷ 1.819 = .517; this is classified as a medium effect size of the treatment on the student's achievement.

Table 6

Paired Sample Statistics for the Two Groups

TREAT			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
A	Pair 1	D7ANC D9ANC	.941	1.819	.441	1.876	.006	2.133	16	.049
B	Pair 1	D7ANC D9ANC	.220	1.632	.231	.684	-.244	.953	49	.345

At this point I wanted to make sure that other factors did not have an influence on the results. Two independent paired t-tests were run to look at the influence that group composition might have had on the results, for example, male verses female, aboriginal verses non-aboriginal. Table 7 shows the results of these tests.

The first test revealed no significant difference in achievement based on gender (t = .360, df = 65, p = .720). The test also checked if the variance, or distribution around the mean, was different. Since the t-value was .360 for equal variance and .358 for unequal variance the difference between the two was less than 2, and therefore insignificant. Equal variance will be assumed.

When a student's ethnic background was checked for significant difference in the achievement, the second test shows it was not a significant factor (t = 1.112, df = 65, p = .270). Based on these results I expected that any differences that occurred in mathematical achievement were related to the student's ethnic background.

Table 7

Paired T-tests Results for Gender and Aboriginal/nonaboriginal.

	Levene's Test for Equality of Variances		t-test for Equality of Means				
	F	Sig.	t	df	Sig. (2-tailed)	Mean Diff	Std. Error Diff
Gender							
Equal variances assumed	.126	.724	.360	65	.720	.151	.418
Equal variances not assumed			.358	62.09	.722	.151	.420
Aboriginal &Nonaboriginal							
Equal variances assumed	3.13	.082	1.112	65	.270	.503	.452
Equal variances not assumed			1.250	47.59	.217	.503	.402

Univariate analysis, ANCOVA, was run to compared the whole pre-test to the entire post-test to see if there was any significant findings between the students in the more innovative group with those in the more traditional group. The results are shown in Table 8. The test indicated weak ($\alpha = .10$) significant difference between the treatment groups: $F(1,67) = 3.579$, $p = .063$.

Table 8

Univariate Analysis of the Two Treatment Groups.

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power(a)
DMAT7	Hypothesis	847.605	1	847.605	63.047	.000	63.047	1.000
	Error	860.411	64	13.444(c)				
TREAT	Hypothesis	48.110	1	48.110	3.579	.063	3.579	.590
	Error	860.411	64	13.444(c)				

Therefore, based on this analysis I make the claim that the more innovative teacher's students displayed greater mathematical achievement than the students from the classes with traditional teachers. Therefore teachers with innovative teaching styles can enhance the learning of their students.

CHAPTER 5: DISCUSSION

There are four sections to this chapter; the first provides a summary of the study, the second discusses limitations of the study, and the next sections addresses implications for further research and for practice.

Summary of the Study

The literature indicates the need for a variety of teaching strategies. One very important aspect to every classroom is learning through discourse. Besides the internal benefits that class discussions allow discourse also provides a teacher will valuable information on the depth of student understanding. Students also need to be actively involved in the learning process, not just spectators. Discovery and experimentation allow students to gain knowledge for they can replace a less effective reliance on just memorization.

My research project showed student improved more in the group, in which the teacher used a greater variety of teaching strategies than the students, whose teachers reveal less variety. Teacher A's teaching practices included the use of calculators, manipulatives, computers, and videos for every unit. This teacher used discovery activities more frequently than the others if they used them at all. Teacher A used journal entries on a daily basis where the others did not indicate the use of journals regularly. The teacher A reported having intentionally used Bloom's Taxonomy and the Theory of Multiple Intelligences in planning and executing the mathematics lessons the others indicated they did not consciously incorporate these organizers into their mathematics lessons. According to my interpretation Teacher A used more varied teaching strategies and, as a result, the students in class A showed the greatest learning gains during their mathematics course.

Limitations of this Study

The sample size for this study was small, with only four teachers and sixty-seven students. The innovative group only had seventeen students. The quality of the results of the study was dependent upon how seriously the students took the test. Did they put forth their best effort? This is something over which I had no control.

The study was limited in that the teacher questionnaire was the only means through which teaching strategies were assessed; teachers were not observed directly. Thus the questionnaire provided a limited glimpse of how each of the teachers actually taught. I did not have an exhaustive list of teaching practices so the other teachers may have had other strategies that I was not aware of because of this. In some cases, responses may have been less reliable because the teacher may have had the knowledge or skill I was searching for but may not have known the particular terminology I used. In addition, I did not get to experience the teachers' interactions with students. It is not only what teachers do, but also how well they do it and how well they function in their class that is significant for student learning.

The search for factors that might have influenced this study focused on the standard ones, including gender and aboriginal or non-aboriginal heritage. Other factors such as socio—economic status were not considered in this study. Neither the education levels of the students' parents nor the quality of the students' home environments were considered as factors that may have influenced learning as assessed through test results.

Implications for Further Research

Further research is still needed. A larger sample and a look at some of the factors, not considered, need to be studied to provide more credibility for the findings. Investigative practices need to be performed by classroom teacher who would have more control over the procedures and particular strategies that are tried. Direct observation of teachers should be done to include their interactions with the students. When groups of students show learning differences, research needs to look beyond ethnicity and gender to see what underlying causes, besides physical appearances, may have put these students at a disadvantage including their parents' educational achievement, the socio-economic background, and the home environment conditions.

Implications for Practice

Teaching needs to change from the teacher simply imparting information to the students, to the teacher being a catalyst who inspires students to learn. Changes in the educational system will be minimal until teachers get the support and encouragement they need to step out their comfort zone, or current ways of teaching, and try other tactics and strategies that will increase their instructional repertoires. Such change does not mean throwing everything out and starting over but adding something new for a lesson, chapter, and a unit per day, week, month, or year. Teacher need to stay abreast of current teaching practices and research to give them insight on how to better prepare for the needs of the students. Times are changing and teachers need to change with them. Failure on the part of educators is not an option.

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Appendix A – Letter to Teachers

To: Grade 8 Math Teachers
School District 91

From: Debra K. White
Box 1651
Vanderhoof, BC V0J 3A0
250-570-0090

RE: Proposed research

Hello, I am a graduate student currently enrolled at UNBC working on my Master of Education with and emphasis in Curriculum and Instruction. My goal is to gather information on teaching strategies currently being used and to assess strategies that enhance student achievement the most. Having been a teacher for twenty years, I have always been curious about new teaching approaches and how they might improve learning in my classroom. The work that I have done for my Master's program has accentuated this desire to know. This matches up nicely with one of your School District 91 goals, to gather information on "current practice being utilized to teach mathematics in classrooms throughout the district [and] to research new and current trends being used in teaching mathematics". My research will allow me to finish my Master's program requirements and hopefully benefit your school district in the process.

My study would require you, the grade 8 math teacher, to administer the School District 57 (Prince George) District Mathematics Achievement tests (DMAT), specifically the DMAT 7 as a pre-test in the fall of 2004 and the DMAT 9 as a posttest in January 2005. Dr. Peter MacMillan, has recommended these tests to me because of his knowledge of their reliability and validity for their intended purpose. In order to document teaching practices, I would like each of you to fill out a survey in the fall about the teaching strategies that you are currently using. Copies of the survey will be available the beginning of November. The focus will be on teaching methods being used and not the teachers and their abilities. I need a signed consent form from each teacher. Participating in this study is totally voluntary and you, the participant, have the right to withdraw at any time. There is no remuneration for participating.

This district was chosen because I reside in Vanderhoof. I contacted Gordon Milne of SD #91 about the possibility of conducting this research. I received his support pending school board approval and willingness of teachers to participate. No school or teacher will be identifiable in the final report. Although I will know the names of participants and necessarily be able to link their comments and classroom achievement to them, all records will be kept in a secure place that is accessible only to me. These documents may be shared with my thesis supervisor during my research. Anonymity and confidentiality will be maintained at all times. All records will be destroyed following the completion of the research, including thesis/project writing and attempt(s) at publication in a refereed journal.

I will give the school district a copy of my thesis and make the results of my work available to school district mathematics committee for dissemination as they see fit.

Thank you for your consideration in this matter.

Sincerely,

Debra K. White	Dr. Willow Brown
delmardebra@uniserve.com	brown@unbc.ca

Any complaints about the project should be directed to the Vice President Research, 960-5820. Copies of signed consent will be made available upon request.

Appendix B – Letter for Permission to use DMAT

May 13, 2004
Bonnie Chappel
School District No. 57
Prince George, BC V2N 4Z9

Dear Bonnie Chappel,

I am in the process of writing a Master of Education thesis research proposal. For my study I would like permission to use Prince George's District Mathematics Achievement tests (DMAT), specifically the DMAT 7and the DMAT 9 in the fall. I would be responsible for preparing the copies needed and all copies would be returned to me so results can be analyzed for my thesis. All research would be carried out under the supervision of my supervisor, Dr. Peter MacMillan.

Sincerely,

Debra K. White	Dr. Peter MacMillan
delmardebra@uniserve.com	peterm@unbc.ca

Hi Debra,

Yes, you have School District No. 57's permission to use our District Math Tests for your research. Good luck in your endeavours.

Bonnie Chappell

Bonnie Chappell,
Director, School Services
School District No. 57 (Prince George)]
1894 Ninth Ave,
Prince George, B.C. V2M 1L7
250-561-6800 ex 311

Appendix C – Letter to District 91 Superintendent

May 11, 2004
Superintendent Gordon Milne
School District No. 91 (Nechako Lakes)
153 Connaught
Vanderhoof, BC V0J 3A0

Dear Mr. Milne:

I am in the process of writing a Master of Education thesis research proposal that will be submitted to the UNBC ethics review board for approval. All research would be carried out under the supervision of my supervisor, Dr. Peter MacMillan. When I spoke with you several months ago about conducting my research in the Nechako Lakes School District, I indicated that I would like to gather data from grade eight mathematics teachers and their students. My goal coincides with your district goal to gather information on "current practice being utilized to teach mathematics in classrooms throughout the school district" and to research new and current trends being used in teaching mathematics.

My study would use the School District 57 (Prince George) District Mathematics Achievement tests (DMAT), specifically the DMAT 7 as a pre-test in the fall of 2004 and the DMAT 9 as a posttest at the end of this first semester. My supervisor had recommended these tests to me because of his knowledge of their reliability and validity for their intended purpose. We are in the process of obtaining permission to use them for this proposed study. In order to document teaching practices, I would like to have the grade eight mathematics teachers complete a survey on teaching strategies that they are currently using Also I wish to observe their classrooms and interview these teachers sometime during the first semester. Anonymity of the schools, teachers, and students will be preserved with the actual identities of these people known only to my supervisor and myself.

At the time we had spoken, you had given me oral consent for this research but I would like to have this in writing so that information can be included with my written UNBC proposal. I recognize this agreement was conditional, based on UNBC ethics board approval and consent from the Nechako Lakes District School Board. Thank you for whatever assistance you can give me

Sincerely,

Debra K. White	Peter D. MacMillan
delmardebra@uniserve.com	peterm@unbc.ca

Appendix D – Letter Sent to Parents

To Whom It May Concern:

I am a graduate student at UNBC working or my Master in Education in Curriculum and Instruction. In an effort to complete my thesis I would like to gather data from grade eight mathematics teachers and their students. My goal coincides with School district 91's goal to gather information on "current practices being utilized to teach mathematics in classrooms throughout the school district" and to research new and current trends being used in teaching mathematics.

My study would use a pre-test in the fall of 2004 and a posttest at the end of this first semester administered by the classroom teacher. Anonymity and confidentiality of the schools, teachers, and students will be preserved with the actual identities of these people known only to my supervisor and me.

This letter is to inform you of a study proposed for your district this semester. If you have any concerns please feel free to contact me.

Sincerely,

Debra K. White	Dr. Willow Brown
delmardebra@uniserve.com	brown@unbc.ca

Appendix E – Questionnaire for Teachers

Questionnaire on Teaching Strategies

Name: ______________________________________

School: _____________________________________

Please check the frequency that best fits your style of teaching. Feel free to add any explanations.

	Daily	Weekly	Per/unit	Seldom
PRESENTATION OF MATERIAL				
Lectures (oral)	_____	_____	_____	_____
Notes (written out)	_____	_____	_____	_____
Demonstrations/	_____	_____	_____	_____
Modeling	_____	_____	_____	_____
STUDENT WORK				
Individually	_____	_____	_____	_____
Pairs	_____	_____	_____	_____
Group	_____	_____	_____	_____
Discussions	_____	_____	_____	_____
Written	_____	_____	_____	_____
Use computers	_____	_____	_____	_____
Use calculators	_____	_____	_____	_____
Videos	_____	_____	_____	_____
Manipulatives	_____	_____	_____	_____
Long-term activities	_____	_____	_____	_____
Short-term activities	_____	_____	_____	_____
Discovery activities	_____	_____	_____	_____
Problem solving activities	_____	_____	_____	_____
ASSESMENT				
Written (Traditional)	_____	_____	_____	_____
Oral	_____	_____	_____	_____
Portfolios	_____	_____	_____	_____
Rubrics	_____	_____	_____	_____
Journals	_____	_____	_____	_____

Please answer the following questions.

1. How do you plan lessons?

2. What sort of things do you include in your lesson plans? (Possible questions, sources, projects…)

3. Do you tend to focus on teaching students the concepts or the mechanics of working math problems? Why?

4. Do you teach story problems as a unit, scattered throughout, or not at all? Why?

5. Do you teach the social skills needed for group work explicitly? Comment.

6. Do you have a relatively fixed or varied teaching style?

7. Do you use Bloom's Taxonomy to form oral and/or written questions? Comment.

8. Does the research on Multiple Intelligences influence your lesson plans? Comment.

9. Do you use graphic organizers? If so, name some of your favorites.

10. Do you encourage student discourse and other types of interaction? Please elaborate.

11. Describe what a typical grade 8 math lesson would look like in your classroom, noting the approximate time spent in each part of your lesson.

SCHOOL DISTRICT 91 NECHAKO LAKES

School District No. 91 (Nechako Lakes)

P.O. Box 129, Vanderhoof, B.C. V0J 3A0
Telephone: (250) 567-2284 Fax: (250) 567-4639

September 16, 2004

Debra K. White
Box 1651
Vanderhoof, BC
V0J 3A0

Dear Debra:

Your request for permission to conduct research involving grade 8 students and teachers for your Master's program was approved on Monday, September 13, 2004, at a meeting of the Board of School Trustees, School District No. 91 (Nechako Lakes). We understand participation is on a voluntary basis.

Your research project is timely, Debra, as we are focused on improving student achievement. We will be very interested in the results of your study on current practices and trends in teaching strategies in teaching mathematics.

We wish you luck on your research and look forward to your sharing the results.

Yours truly,

Gordon Milne
Superintendent of Schools

GM/cp

UNBC UNIVERSITY OF NORTHERN BRITISH COLUMBIA

RESEARCH ETHICS BOARD

MEMORANDUM

To: Debra White

From: Alex Michalos, Chair

Date: June 28, 2004

Re: E2004.0525.060
Instructional Strategies that increase student academic achievement

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Thank you for submitting the above-noted proposal to the Research Ethics Board for review. Approval has been granted.

Good luck in your research.

Sincerely,

Alex Michalos

Alex C. Michalos, Chair
Research Ethics Board